White paper charts R&D path to give electric aviation industry wings

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U.S. Department of Energy's (DOE) Argonne National Laboratory, DOE's Vehicle Technologies Office (VTO), National Aeronautics and Space Administration (NASA) Glenn Research Center

and other experts aim to make electric aviation a reality.

The world of aviation has seen a growing revolution in the last five years with the transition of jet engines to electric motors driven by declining costs and performance improvements of lithium-ion batteries. Electric propulsion offers numerous advantages, including lower fuel and maintenance costs, decreased noise and air pollution and unique aircraft designs.

Estimates suggest that a new mode of aviation services called Urban Air Mobility, or sometimes Advanced Air Mobility, will be a $9 billion market by 2030 and could be an $80 billion market by 2041.

But how do we get to this electrified future? A forward-thinking white paper by the Argonne Collaborative Center for Energy Storage Science (ACCESS) outlines a clear set of battery requirements and research and development needs to accelerate the commercialization of electric propulsion—from air taxis in the near term to 737 class aircraft in the long term.

The white paper is the result of a two-day meeting to understand the unique R&D needs for electric aviation batteries held in December 2019 at the U.S. Department of Energy's (DOE) Argonne National Laboratory. The meeting, convened by DOE's Vehicle Technologies Office (VTO) and the National Aeronautics and Space Administration (NASA) Glenn Research Center, drew nearly 100 experts from aircraft companies, component makers, battery companies, materials companies, car companies and academic and national lab researchers.

The paper explores four aircraft concepts: air taxis, 20-passenger commuter aircrafts, 50-passenger regional jets and 150-passenger, single-aisle 737 class aircraft. For each concept, the paper describes a research

area where DOE and NASA could help spur innovation in electric aviation batteries.

For the air taxi and commuter aircraft market, the paper calls for evaluating next-generation lithium-ion chemistries (e.g., silicon, advanced cathode, lithium-metal) under aviation conditions and examining failure modes and safety. For regional jets, the paper recommends augmenting R&D in solid-state batteries to explore new designs, manufacturing approaches and high temperature operation. And for 737 class aircraft, the paper suggests studying high-energy systems, including sulfur-based batteries and hydrogen carriers, that are far beyond those currently in the R&D pipeline.

"It's clear the next decade will see a worldwide race to commercialize electric flight," said ACCESS director Venkat Srinivasan, a lead author of the white paper. "The convening of the battery and aviation communities helped establish a shared language to ensure that deep knowledge gained from the electrification of ground transport could accelerate the transition for aircraft."

Electric aviation is poised to take off within the next five to 10 years, with innovations already being pursued for electric vehicle batteries playing a significant role in enabling electric aviation. However, differences exist between the two applications that require dedicated focus on mission specific use of the batteries and the unique requirements that it drives, while leveraging some of the advantages offered by aviation-specific missions. In the long term, the energy density needs for electric aviation far outstrip the goals of current DOE and industry investments, requiring strategic thinking around the best approaches to enable this future.

"The white paper findings provide a framework for the development of an investment strategy by the government agencies for battery

technologies specific to electric aviation beyond the current level of investment in the automotive sector," said Ajay Misra, deputy director of Research and Engineering at NASA Glenn Research Center.

Significant investment is being made in the next era of aviation by aerospace companies, including Boeing, Airbus, Rolls, GE, United Technologies, Embraer, Bell and others. In addition, numerous startup efforts in the United States focused on innovations around electric aviation. This includes Uber Elevate that aims to provide affordable shared flights by 2023 with electrification as its core principle. Also, automotive companies, including Daimler, Toyota, Hyundai and Porsche, are getting involved in aviation startups. In fact, Hyundai is in partnership with Uber on a concept air mobility vehicle with a 60-mile range.

"The gains in cost, performance and safety found in today's Li-ion batteries used for electric vehicles are due in a major way to DOE's R&D directed research over the last 10 years," said Dave Howell, acting director of DOE's Vehicle Technologies Office. "Considering the maturity, diversity and innovativeness of that research, DOE has every expectation that similar success will occur for the energy storage needs of electrified aircraft."

Argonne remains committed to driving the electrification of aviation and, during the December meeting, encouraged industry leaders to share ideas that would help them reach shared goals. Argonne has a storied history of battery and energy storage innovations. The Laboratory has helped revolutionize the lithium-ion battery, which became a game changer for the auto industry, noted Suresh Sunderrajan, associate laboratory director for the Energy and Global Security directorate

"While our research for electric vehicles will continue, we are leveraging what we've learned and taking it to the skies," Sunderrajan said at the

December gathering.

In the near-term, lithium-ion batteries could be adapted for short-range aircraft concepts for initial market introduction. Continued electrification and expansion of the electrified aircraft market will occur as battery performance improves and advanced chemistries are adapted for aviation-specific needs. However, electrification of large regional and 737-class aircrafts requires new types of energy storage. So, the next decade will see a global race to commercialize electric flight, according to the white paper.

DOE and NASA plan to organize a future session of this assessment. NASA intends to examine the means to enable R&D to better define the aircraft battery needs and ensure that standards for the industry are developed. DOE plans to include requirements for aircraft in future Federal Opportunity Announcements (FOA) and national lab funding calls.

Then, DOE and NASA will consider organizing a brainstorming session to identify ways for very high-energy density electrochemical energy storage/conversion that could enable electric propulsion for large aircrafts. And the two agencies also intend to organize a brainstorming meeting to standardize battery packs for aircraft and ease the supply chain of cells or packs.

"The United States has the critical mass of expertise in batteries, aviation, propulsion, and system integration to invent the power source for the next 100 years of aviation," the white paper concludes.

More information: White paper: anl.app.box.com/s/xr1wk53shzhvu4w3l57j90t1mhkq01b5

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